Roadway Adaptation and Vulnerability Assessment

Maryland State Highway Administration

March 16, 2017

Maryland Department of Transportation

SHA State Highway Administration

Pilot Study Objectives

- Assess Vulnerability to SHA's Assets
- Develop Approaches to Address Current and Future Risk
- Provide Recommendations for Policy or Process Changes

Floating Debris Lodged in a Bridge during Flood Event at Seneca Creek in Germantown, MD
Photo Source: (FEMA/Skolnik 2006)

"Improve Resiliency of Maryland's Transportation System"

Identify Climate Stressors

Studied in Detail for Maryland

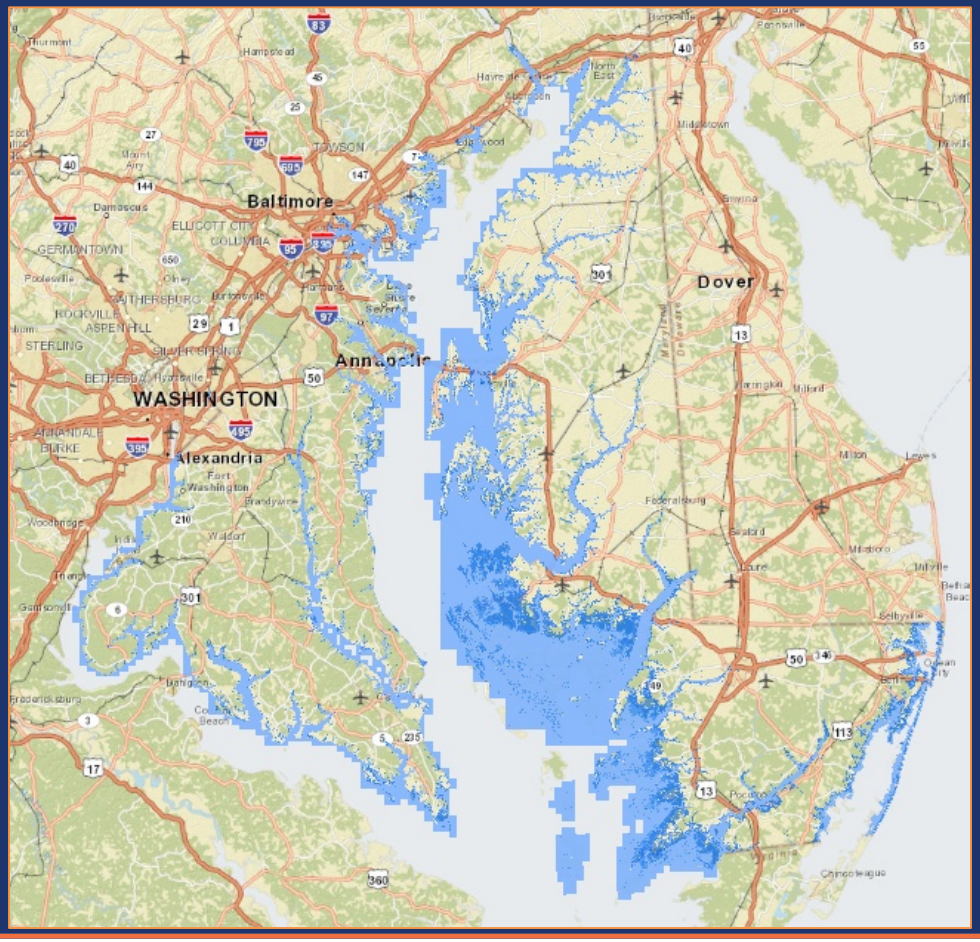
Sea Level Change	• USACE Procedures Established in Circular No. 1165-2-212 (2013) • Newer LiDAR and Assign Nearest Tidal Station
Storm Surge	HAZUS-MH 2.1 (Category 3 Storm Used) Stillwater Depth Grids Developed
Precipitation	• Micro-scale Data Obtained from C-MIP • Riverine Modeling in HAZUS-MH2.1 (future)

2050 & 2100 Sea Level Change

Eastern Shore Regional GIS Cooperative – Salisbury University

		2050		2100	
County	Tidal Station	MSL	MHHW	MSL	MHHW
Allegany	None	-	-	-	-
Anne Arundel	Annapolis	2.08	2.79	5.7	6.41
Baltimore	Baltimore	2.01	2.87	5.59	6.45
Baltimore City	Baltimore	2.01	2.87	5.59	6.45
Calvert	Solomons Island	2.1	2.82	5.76	6.48
Caroline	Cambridge	2.11	3.13	5.78	6.8
Carroll	None	-	-	-	-
Cecil	Chesapeake City	1.98	3.63	5.56	7.21
Charles	Washington DC	2.21	3.83	5.78	7.4
Dorchester	Cambridge	2.11	3.13	5.78	6.8
Frederick	None	-	-	-	-
Garrett	None	-	-	-	-
Harford	Baltimore	2.01	2.87	5.59	6.45
Howard	None	-	-	-	-
Kent	Annapolis	2.08	2.79	5.7	6.41
Montgomery	None	-	-	-	-
Prince Georges	Washington DC	2.21	3.83	5.78	7.4
Queen Annes	Annapolis	2.08	2.79	5.7	6.41
Somerset	Cambridge	2.11	3.13	5.78	6.8
St. Mary's	Solomons Island	2.1	2.82	5.76	6.48
Talbot	Cambridge	2.11	3.13	5.78	6.8
Washington	None	-	-	-	-
Wicomico	Cambridge	2.11	3.13	5.78	6.8
Worcester	Ocean City	2.06	3.25	5.86	7.05

Methodology – USACE: Sea-Level Change Considerations for Civil Works Programs, October 2013



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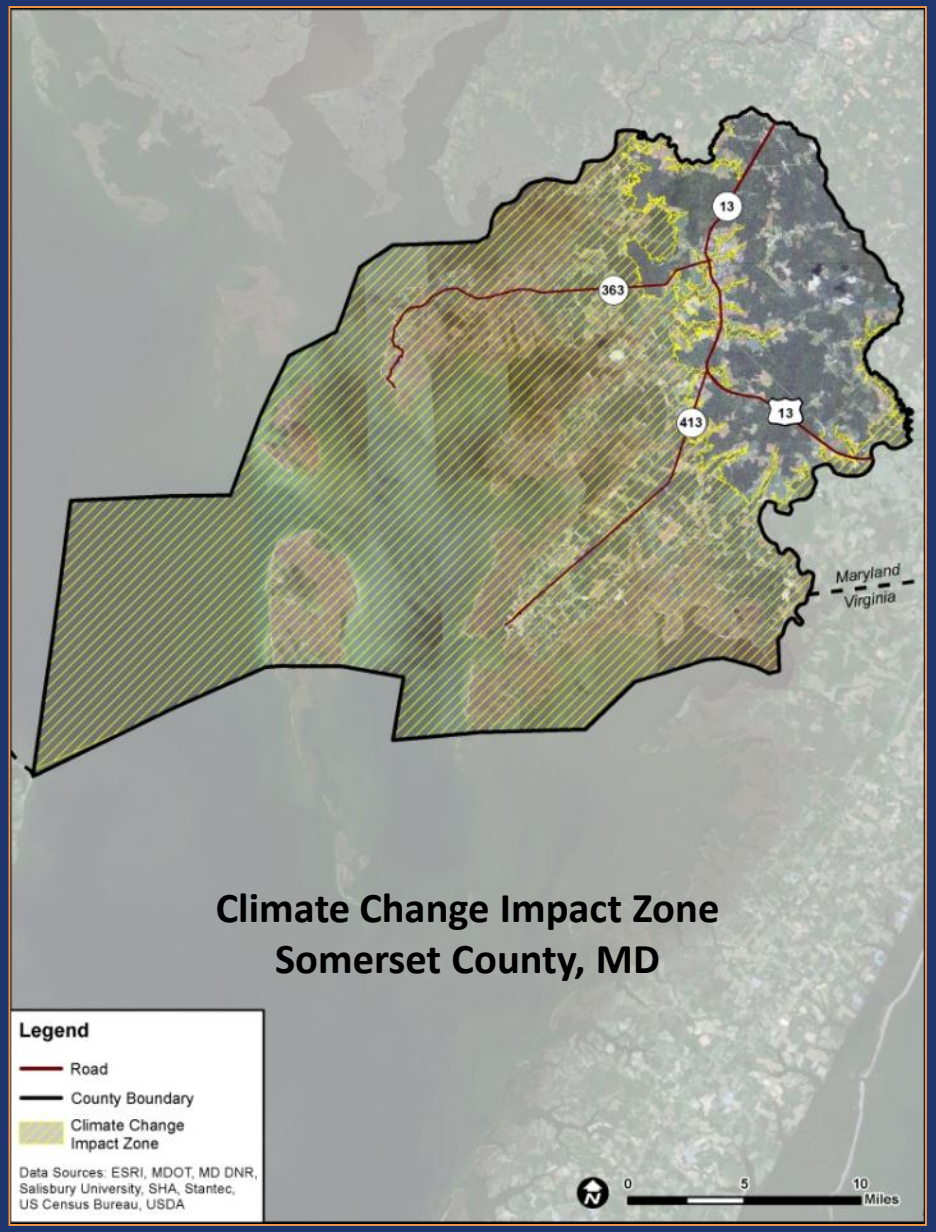
Assess Vulnerability

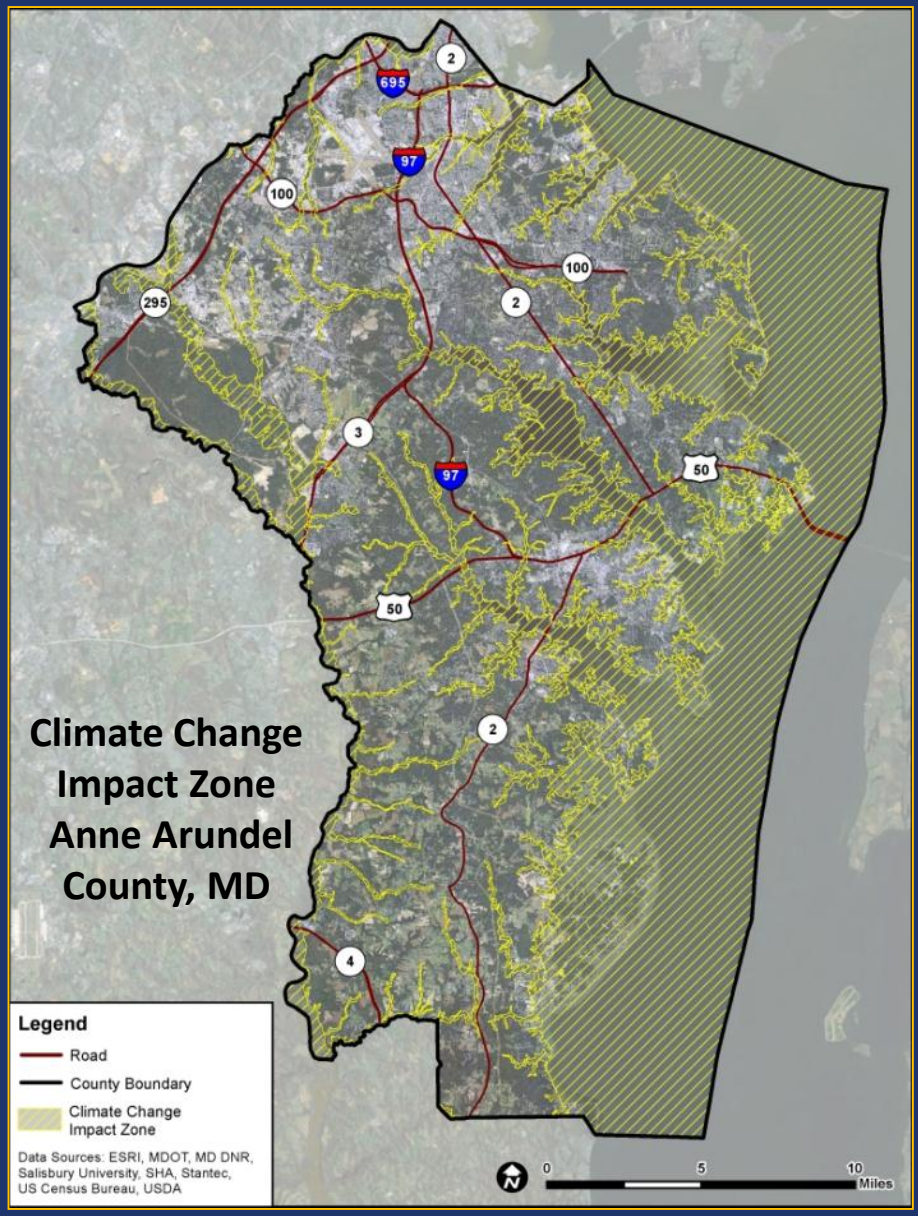
- Two Pilot Counties
- Initial Screening of Assets
- Tools Used
  - Vulnerability Assessment Scoring Tool
  - Hazard Vulnerability Index



Climate Change Impact Zone
Somerset County, MD

Initial Screening

- Climate Change Impact Zone Map Created Using GIS
- Eliminate assets at low to no risk prior to use of VAST
- Used SLOSH (Cat 3), 2100 MHHW, FEMA 100 year Floodplain, plus 50 ft buffer



Results of Screening

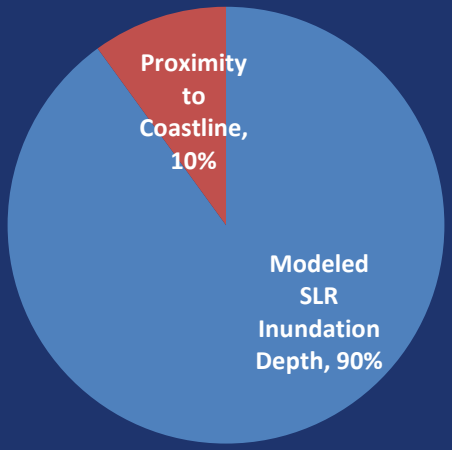
Assets	Anne Arundel County		Somerset County	
	Number of Assets	Evaluated in More Detail	Number of Assets	Evaluated in More Detail
Bridges including large culverts	517	150	86	72
Small culverts and conveyances	Culverts-12,024 Conveyances-8,601	Culverts-1,174 Conveyances-843	Culverts-1153 Conveyances 1135	Culverts-739 Conveyances 847
Miles of roadway	2,554.28 miles	114.99 miles	503.92 miles	285.2 miles

VAST - Input and Results

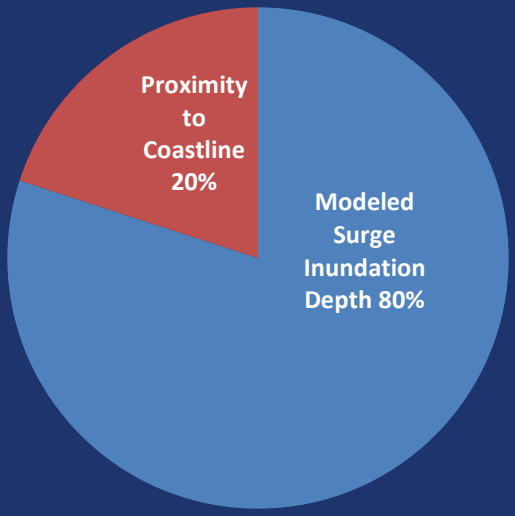
- 150 bridge assets in Anne Arundel County
- 72 bridge assets in Somerset County
- Input Information
  - Asset data
  - Exposure data
  - Sensitivity data
  - Adaptive Capacity data
- Output
  - Vulnerability Score for all structures
  - 10 most vulnerable assets to each climate stressor
  - Maps and tables showing most vulnerable structures

VAST– Exposure Indicators /Weighting

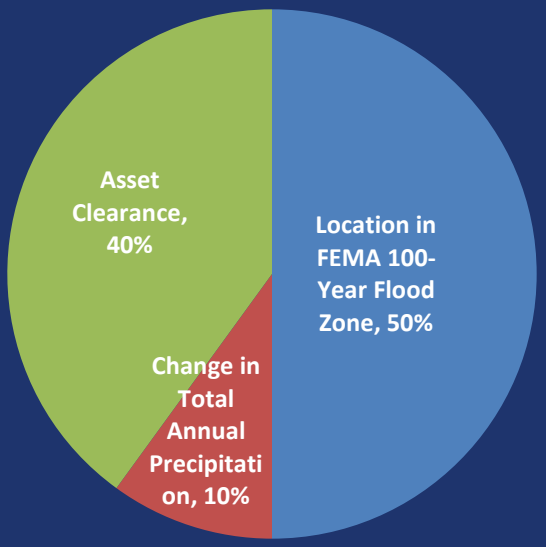
Sea Level Rise



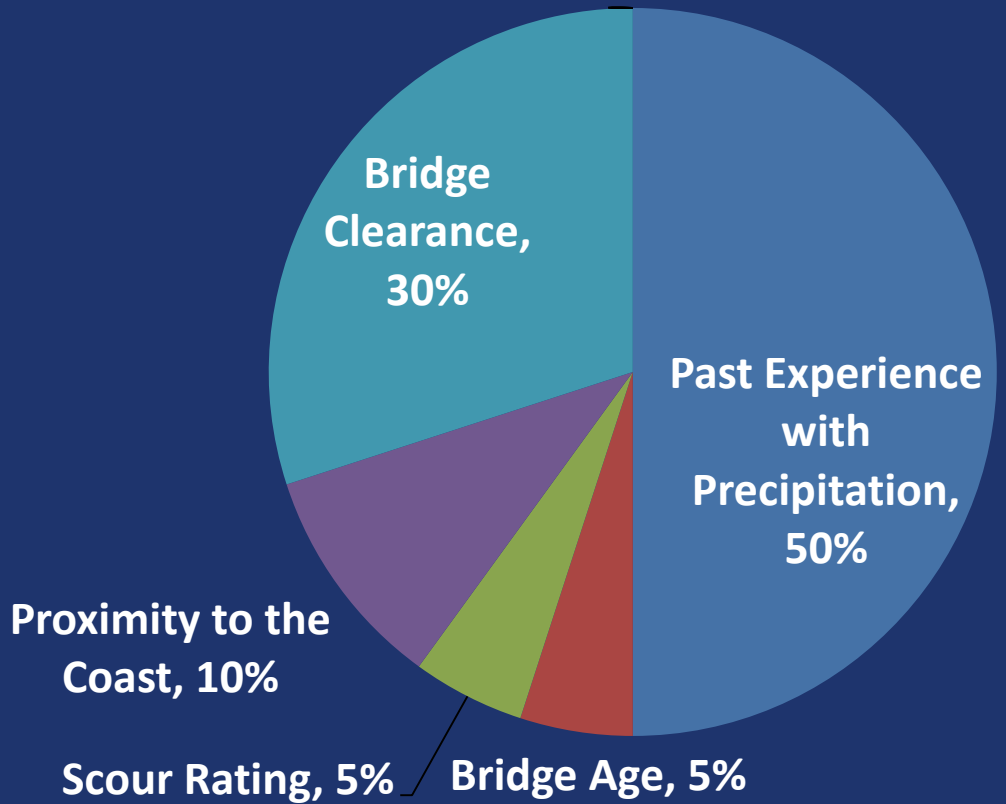
Storm Surge



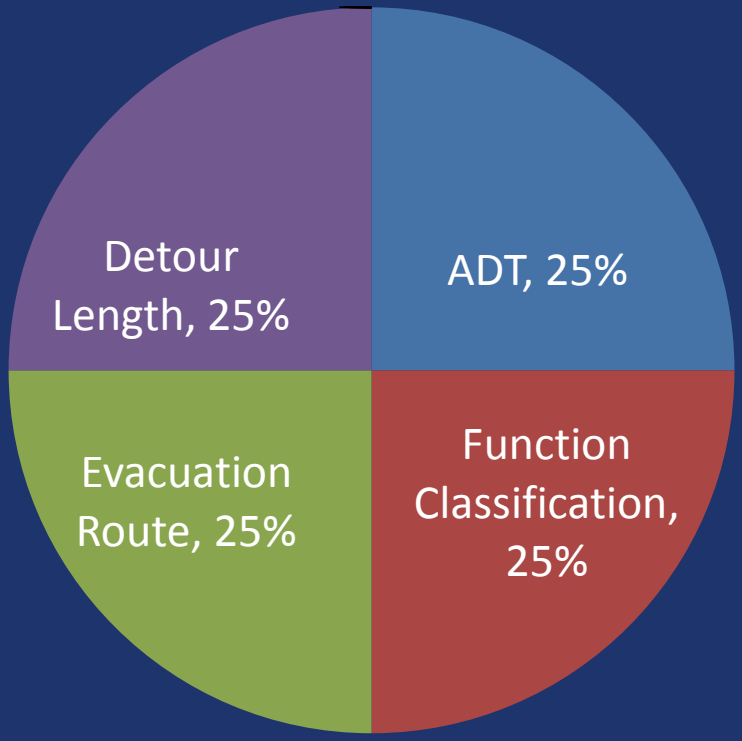
Precipitation



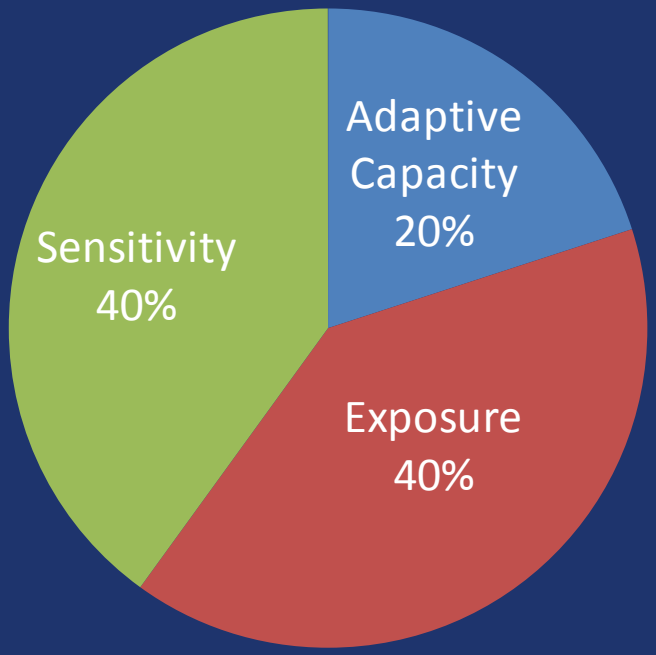
VAST–Sensitivity Indicator/Weighting Precipitation



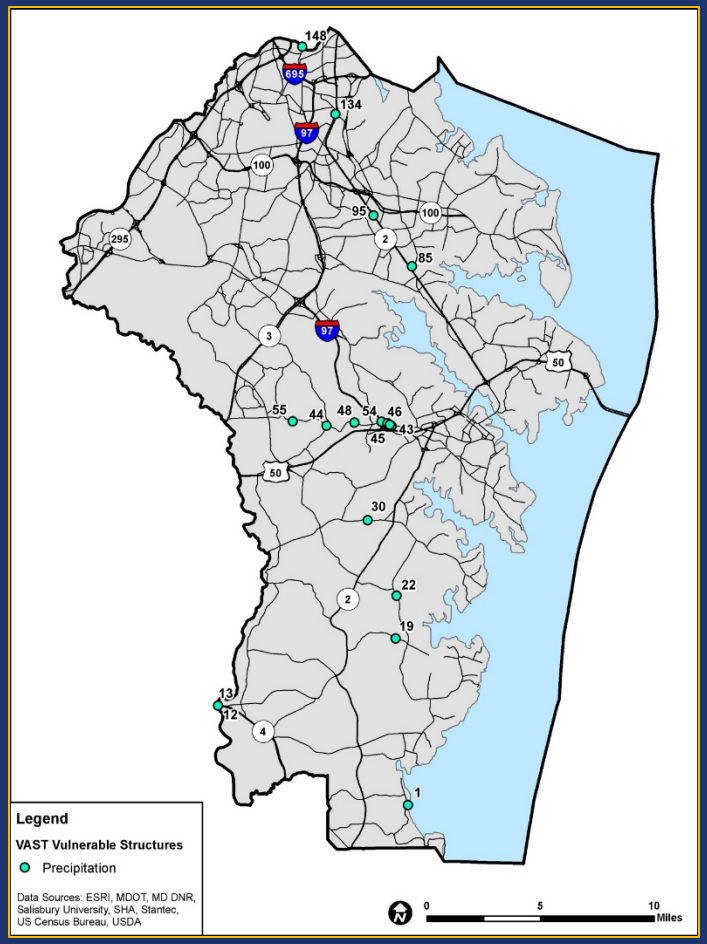
VAST– Adaptive Capacity Indicator/Weighting



Vulnerability Components Weights



FHWA Vulnerability Assessment Scoring Tool Results



Vulnerability to Precipitation		
Structure ID	VAST Score	Evacuation Route
134	3.1	Yes
44	2.8	No
30	2.8	No
43	2.8	No
45	2.8	No
46	2.8	No
1	2.6	No
22	2.6	No
95	2.5	Yes

Hazard Vulnerability Index (HVI)

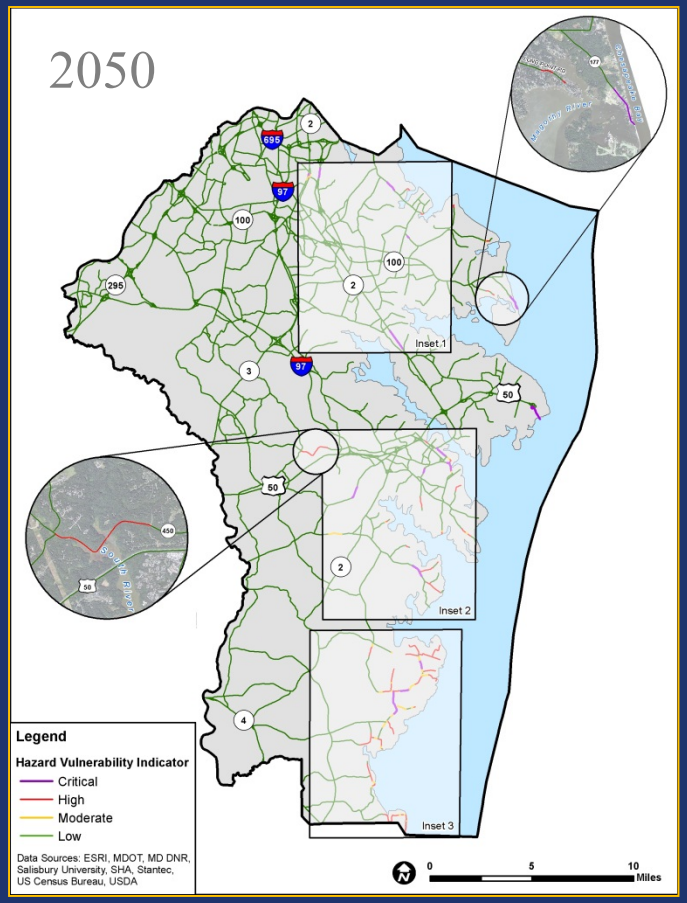
(Evacuation Code*0.5+1) + (Flood Depth Code+0.01)/4 + (0.7/Functional Classification)

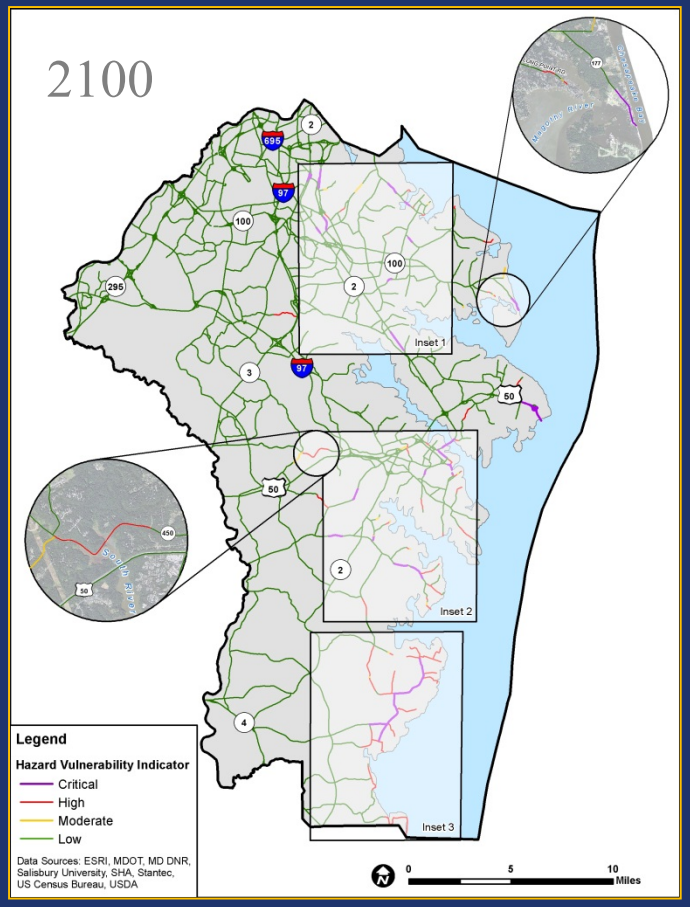
Evacuation	Code
No	0
Yes	1

Flood Depth (Feet)	Code
No Flood	0
0 – 0.5	1
0.5 - 1	2
1 - 2	3
>2	4

Value	SHA Functional Class
1	Interstate
2	Principal Arterial – Other Freeways and Expressways
3	Principal Arterial – Other
4	Minor Arterial
5	Major Collector
6	Minor Collector
7	Local

100-Year Storm HVI for Anne Arundel County





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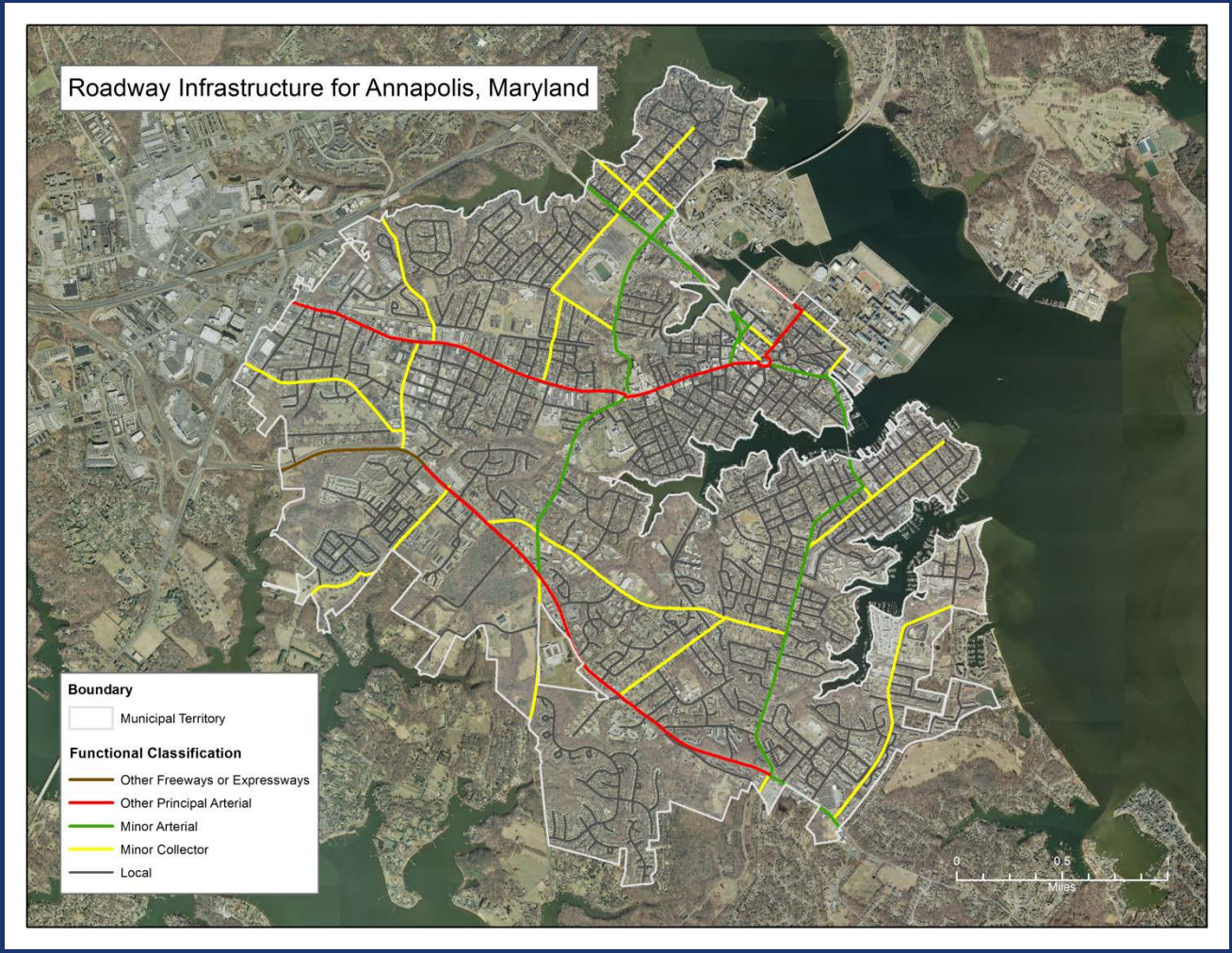
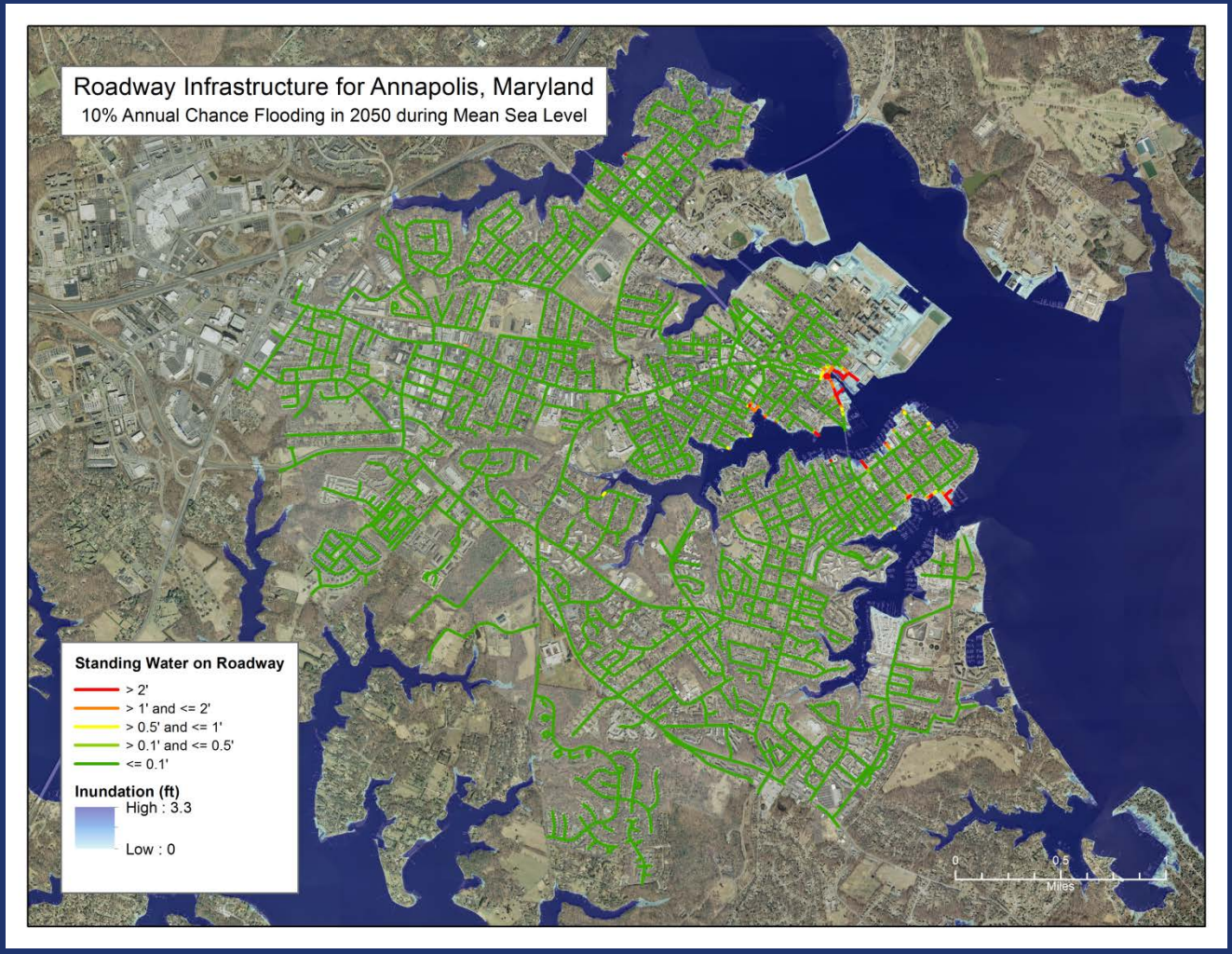
Annapolis Municipal Boundary



10-Year Storm in 2050



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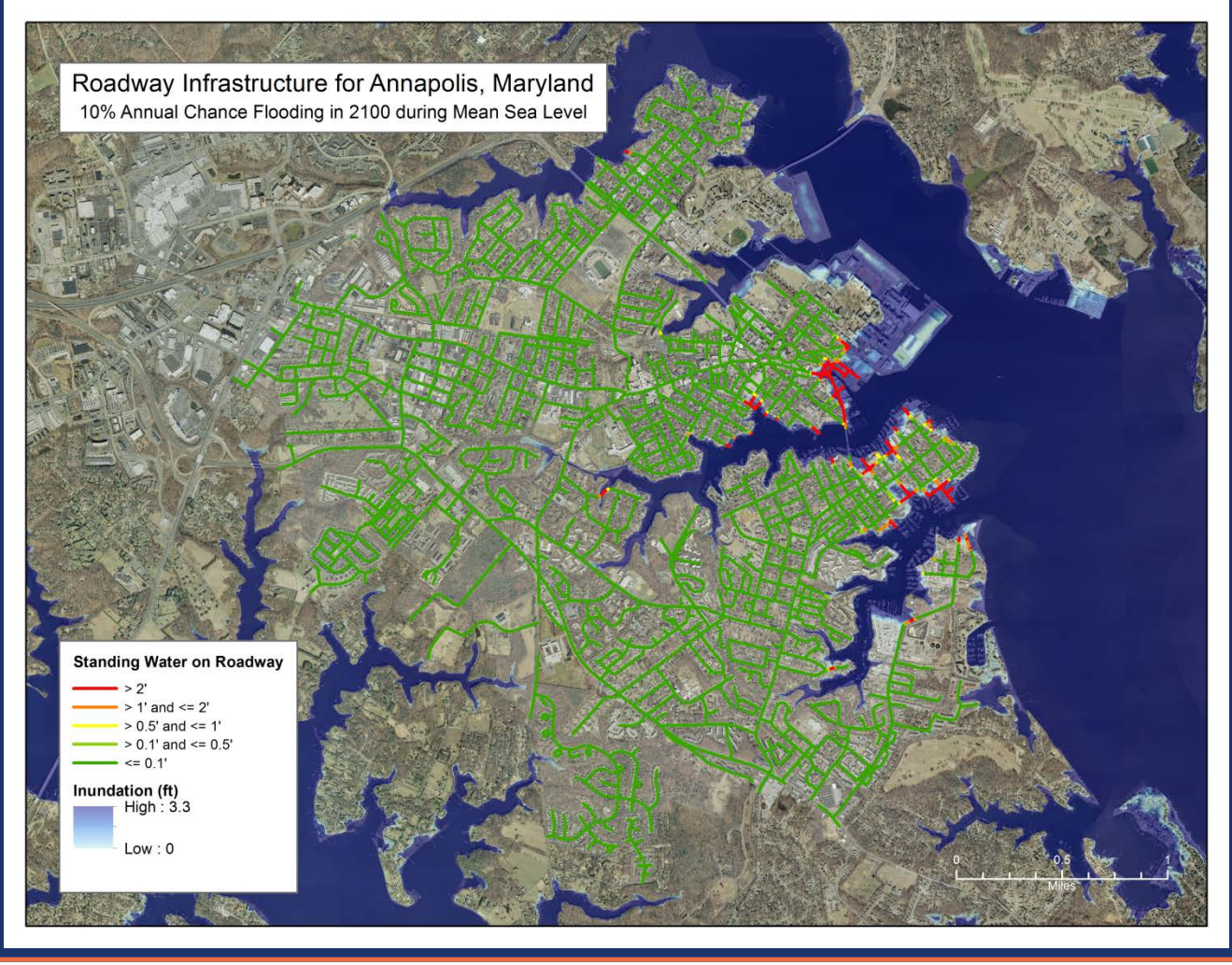
10-Year Storm in 2100



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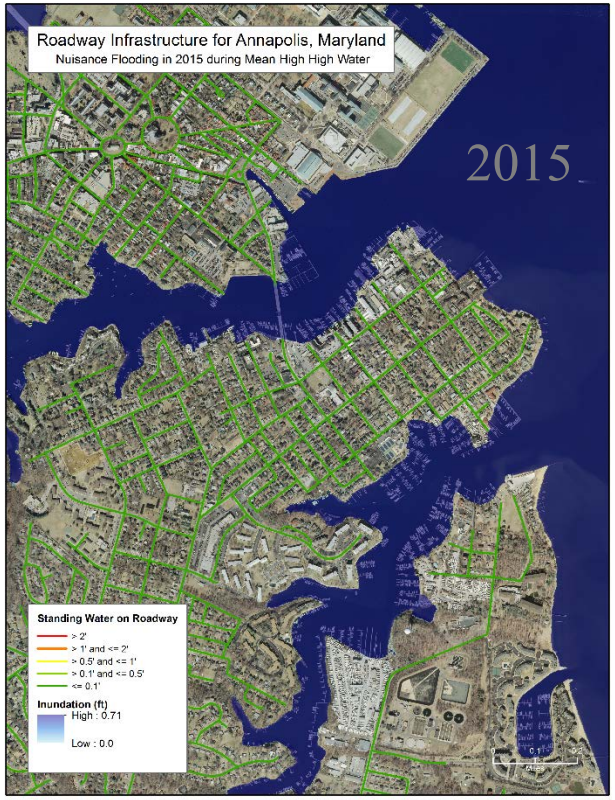
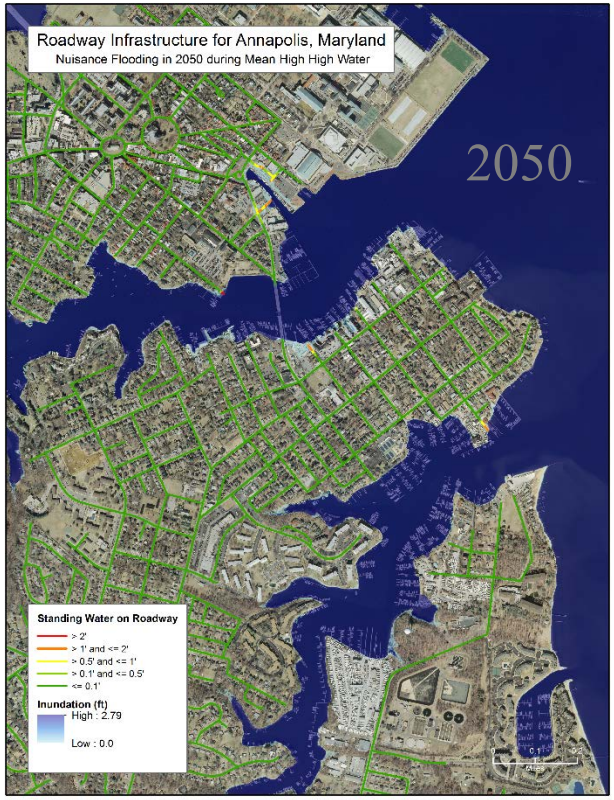
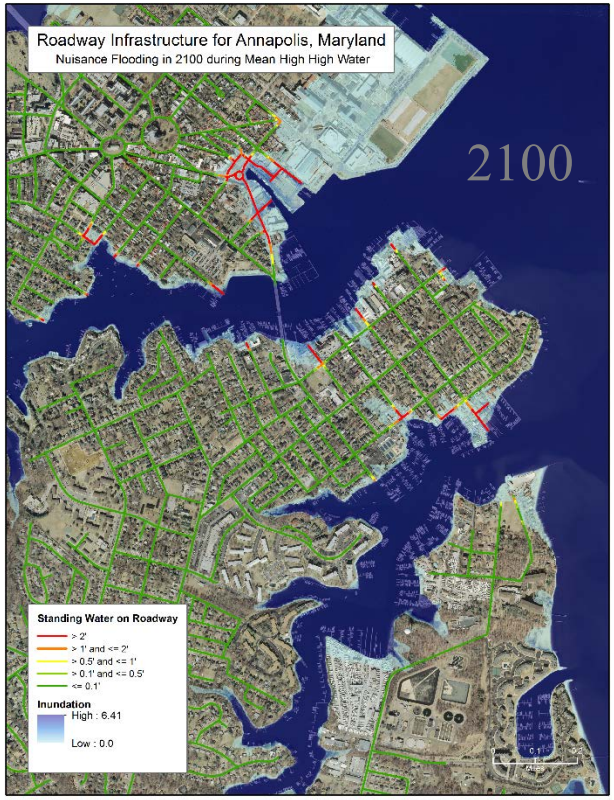
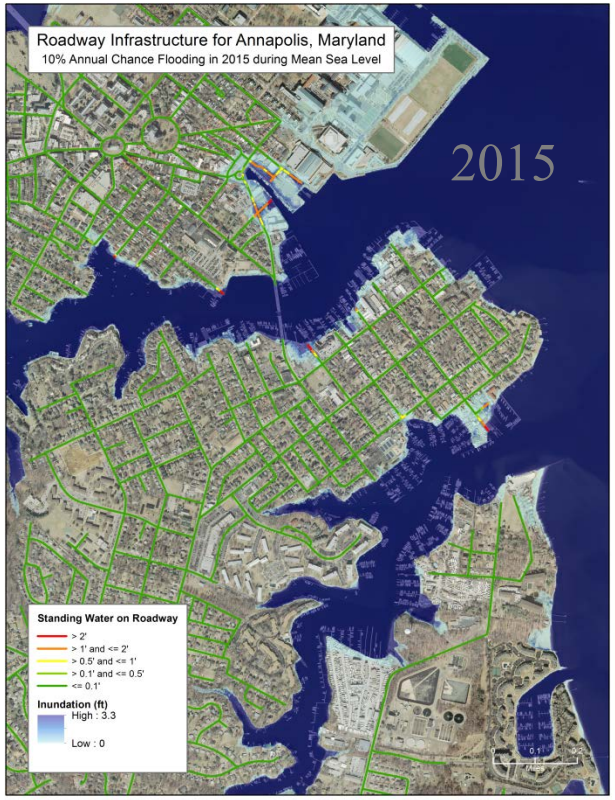
Inundation
Mean Higher High Water (MHHW)

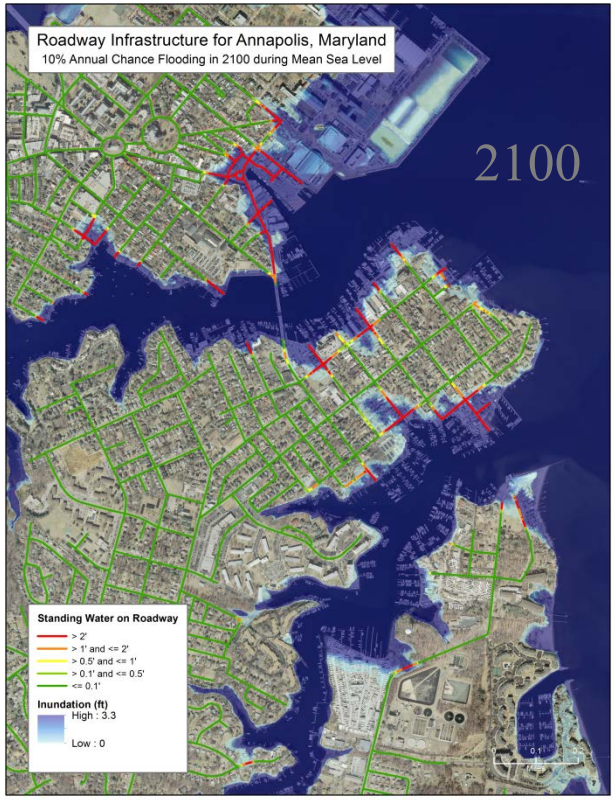




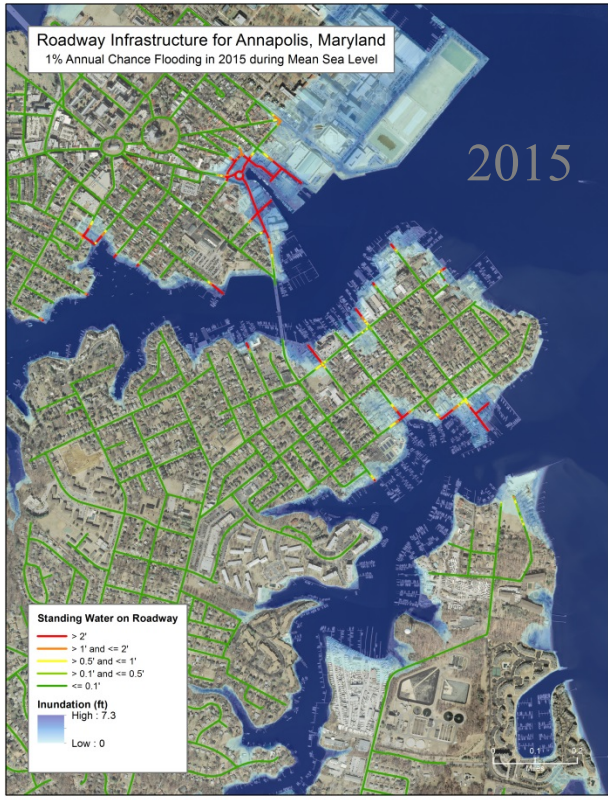


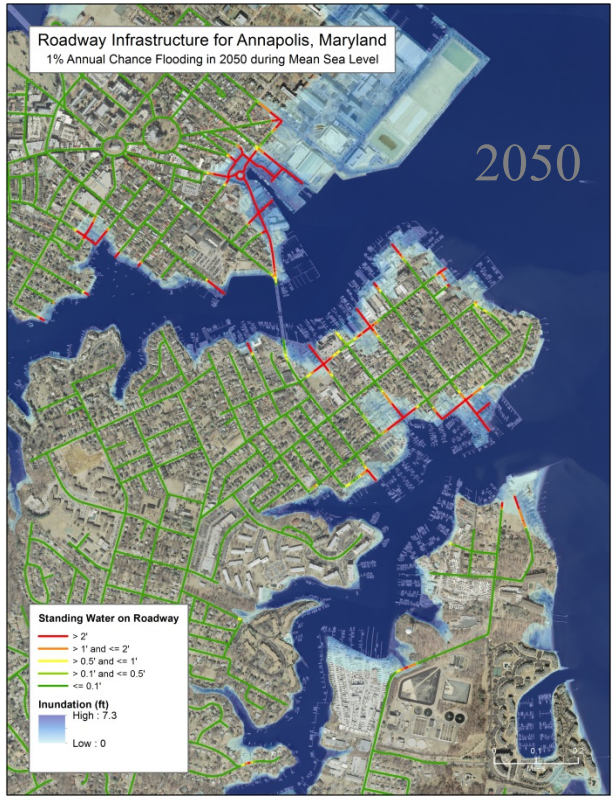
10-Year Storm Inundation
Mean Sea Level

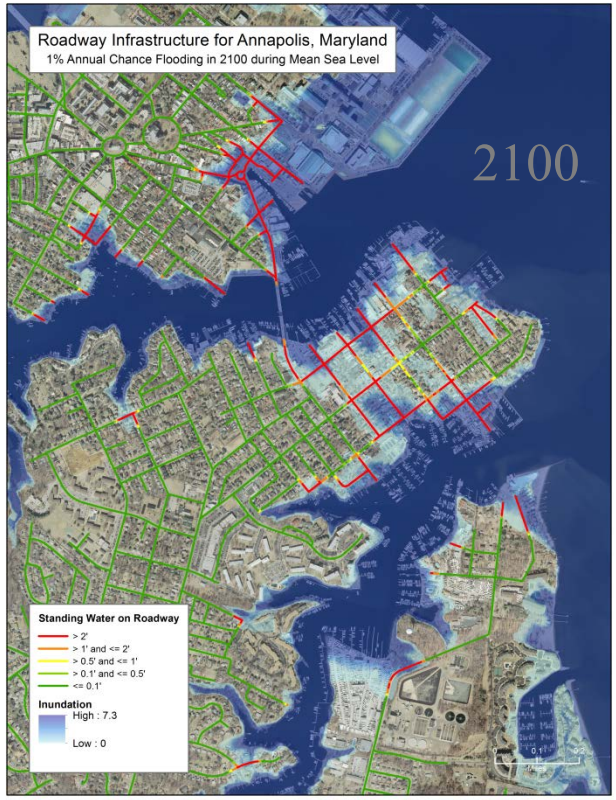




100-Year Storm Inundation Mean Sea Level







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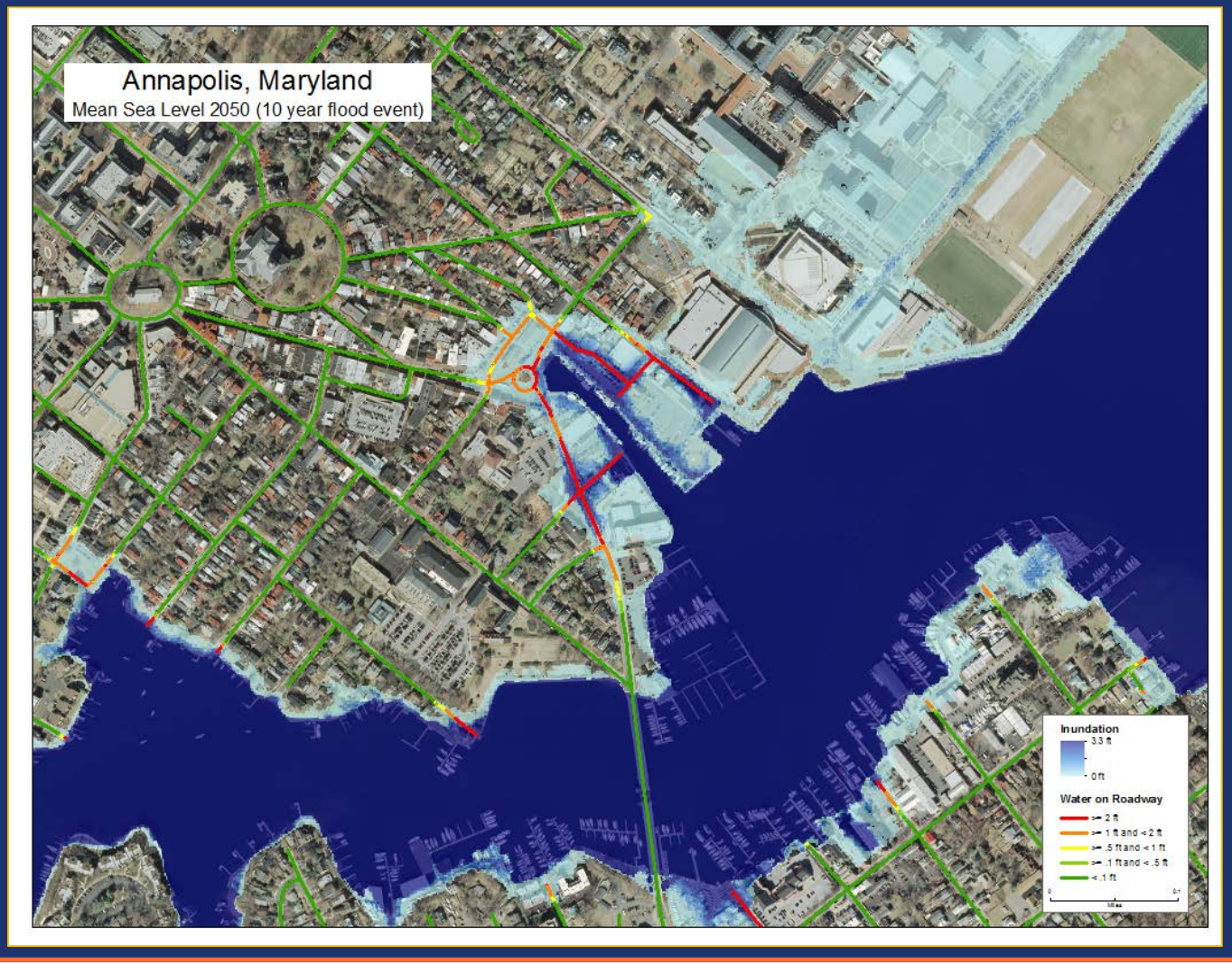
10-Year Storm HVI for Annapolis 2050



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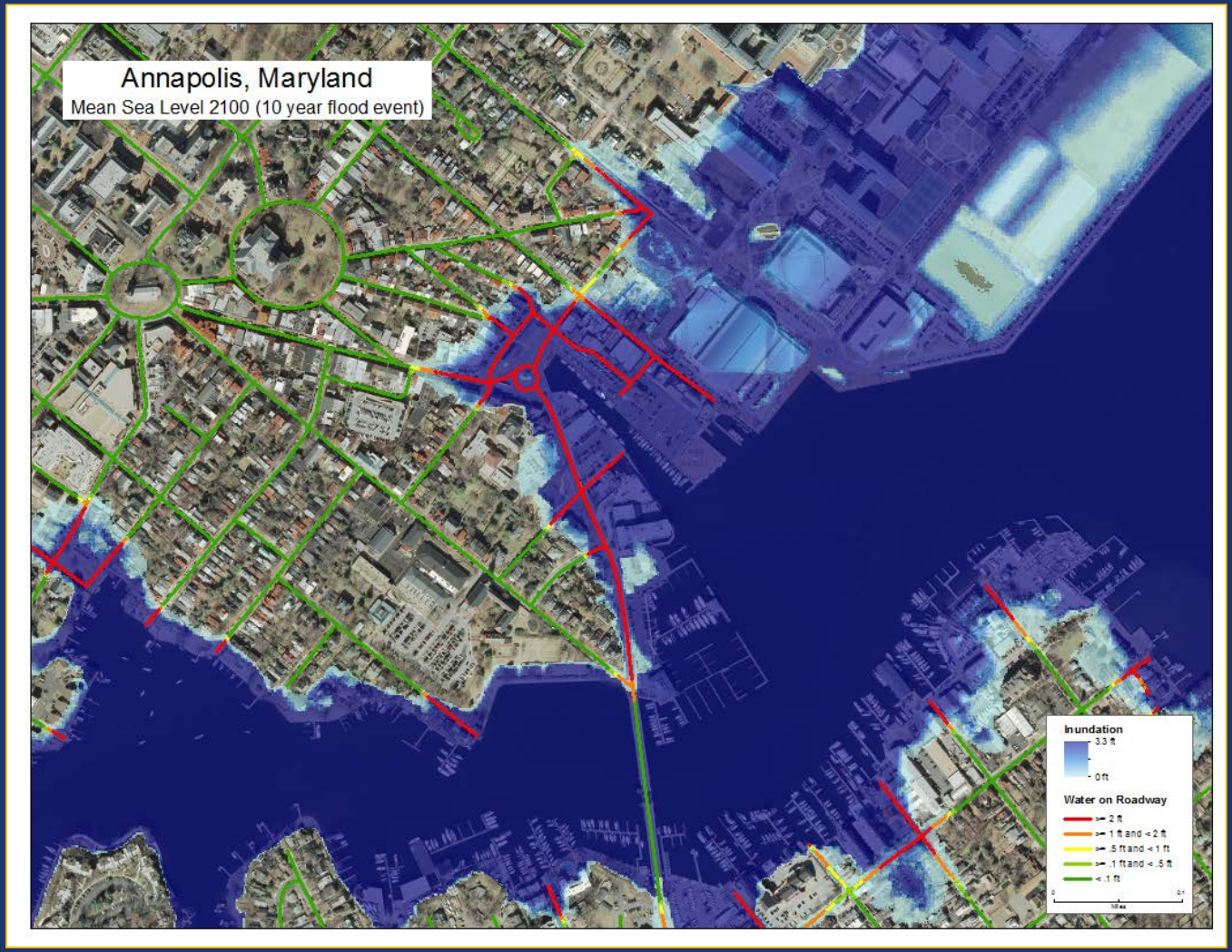
10-Year Storm HVI for Annapolis 2100

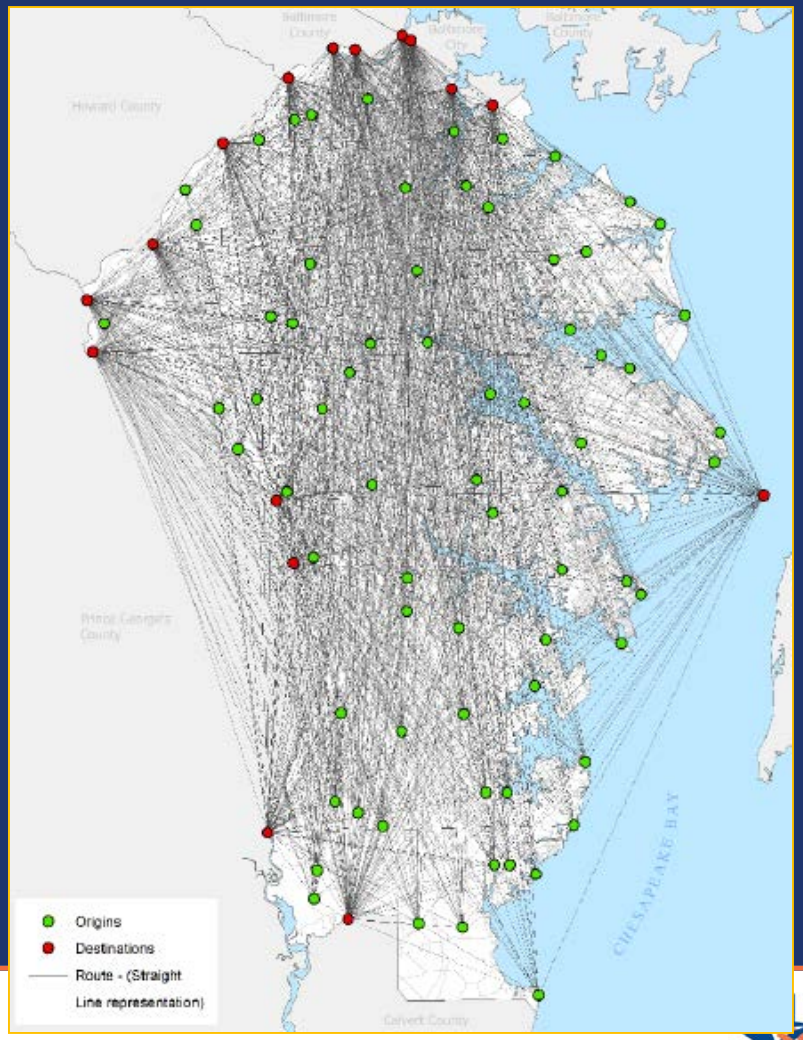


Results

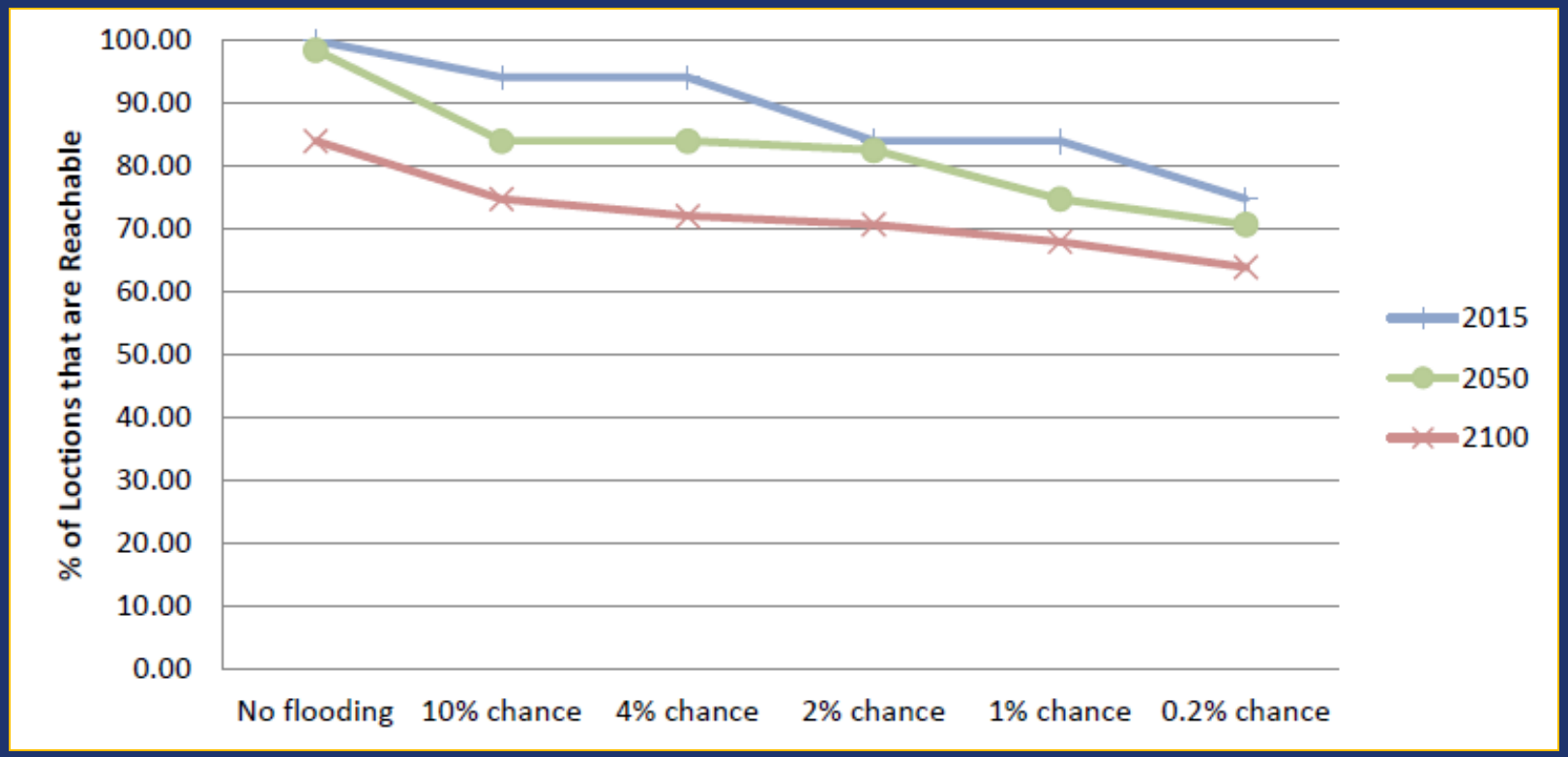
- Anne Arundel County and Somerset County
  - Permanent Inundation
  - 2050 & 2100 Sea Level Change (USACE method)
  - 2050 & 2100 Sea Level Change with 100 Year Storm Event (HAZUS-MH)
  - Storm Surge Considerations (Still Water)
  - Hazard Vulnerability Index (HVI)
  - Vulnerability Scores from VAST for bridges
  - Vulnerable Areas at Risk

Example Origin/Destination Network

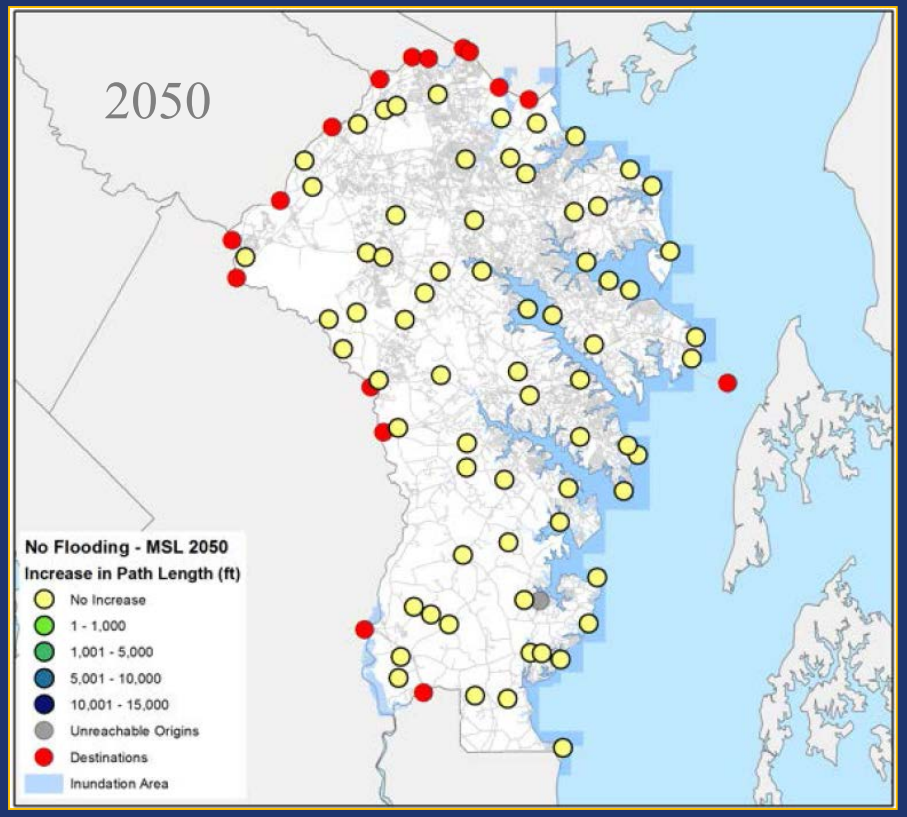
- Evaluate the travel times and access to random locations both before and after a flood event
- 69 Random but evenly distributed Origin and Destination points chosen

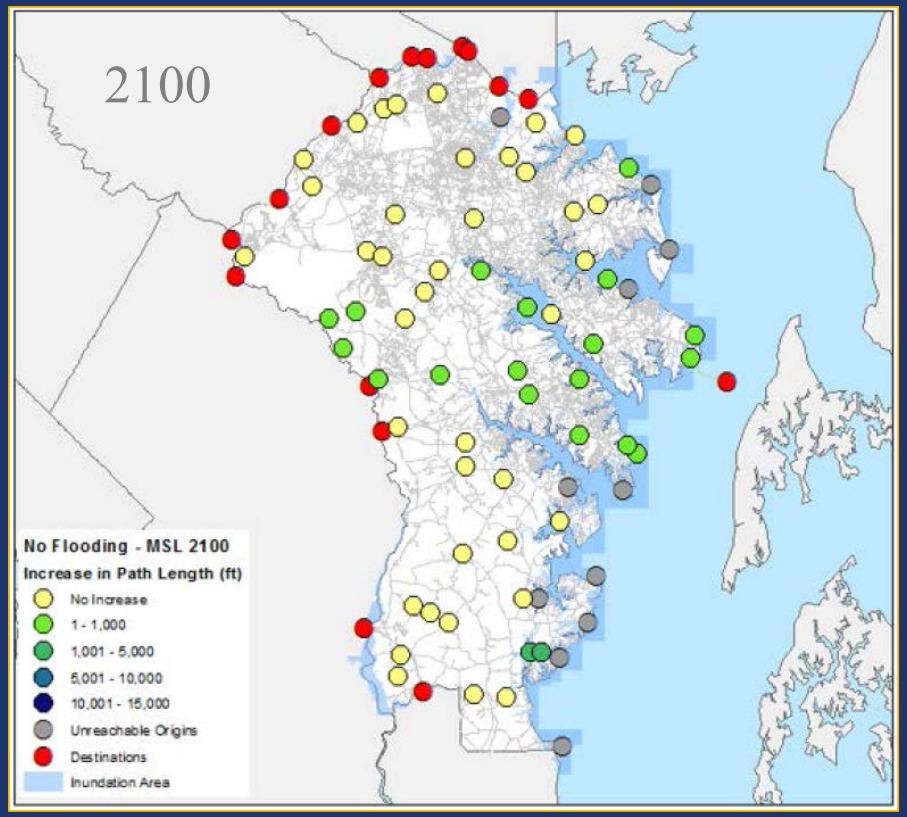


Percentage of Traversible Trace Paths in AA County with MSL SLC



Origin to Destination Analysis





Questions

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Climate Change Adaptation Plan with Detailed Vulnerability Assessment, October 2014

http://www.fhwa.dot.gov/environment/climate_change/adaptation/ongoing_and_current_research/vulnerability_assessment_pilots/2013-2015_pilots/index.cfm